Variation in Ultrasonically Determined Intramuscular Fat in Brangus Cattle


Introduction

Percentage intramuscular fat (IMF) is an important trait in the cattle industry for several reasons. It is economically important because it influences discounts and premiums in grid marketing and is the primary factor used to determine quality grade for carcasses of cattle. Because of its influence on quality grade, it is implicated in palatability and product consistency. Consumers associate U.S.D.A. quality grade with eating quality of meat. In the production segment, as pressure increases to produce a higher quality, consistent product, intramuscular fat will become of increasing importance to seedstock and commercial beef producers.

There is currently some debate whether percentage IMF is under more of an environmental or genetic control, and which factors have an impact on the phenotypic expression of IMF. It is well known that if a trait is heritable, the quickest way to affect the trait is through selection of the parental generation, and especially selection of the sire (Falconer and MacKay, 1996). Recently, there has been much interest in effectively evaluating IMF using ultrasound technology (Brethour, 2000; and Hassen et al., 2001). Hassen et al. (2001) reported that Critical Vision Software is the more accurate predictor of IMF, and a correlation of about 0.61 has been reported for actual carcass IMF (ether extractable equivalent) from the LMA image.

Experimental Procedures

Purebred Brangus cattle were subjected to Real-time ultrasound evaluation for estimation of body composition. Ultrasound measurements were taken in accordance to Beef Improvement Federation guidelines (BIF, 1996) for percent intramuscular fat (IMF), longissimus muscle area (LMA), and 12-13th-rib fat thickness (FT). In addition to ultrasound data, birth weight (BRW), weaning weight (WWT), yearling weight (YWT), and scrotal circumference (SC) were taken in accordance to Beef Improvement Federation guidelines. Body composition, and traits recorded were the 12th and 13th rib subcutaneous fat thickness (FT), longissimus muscle area (LMA), and percentage intramuscular fat (IMF). Performance data provided by the International Brangus Breeder’s Association (IBBA) included: birth weight (BRW), weaning weight (WWT), yearling weight (YWT), and scrotal circumference (SC). Data were analyzed to determine genetic relationships with the animal model using multiple trait restricted maximum likelihood (MTDFREML) procedures. Contemporary group was included in the model as a fixed effect, and age of days was included as a covariate. Analyses of covariant models were examined to determine the relative importance of sire and carcass traits to percentage IMF. Genetic correlations of IMF with LMA, FT, and YWT were –0.25, 0.36, and 0.31, respectively, indicating that as LMA increased IMF decreased. Sire, FT, and LMA were important (P < 0.05) sources of variation in percentage of IMF; BRW, WWT, YWT, SC, and age did not (P > 0.05) influence percentage IMF. These data suggest that percentage of IMF is under genetic control of a quantitative nature, and therefore should be considered when selecting for increased quality grade.

Story in Brief

The objectives of this research were to determine: 1) the effects of sire on the expression of intramuscular fat, and 2) the relationship of intramuscular fat to selected performance traits. Purebred Brangus cattle were subjected to Real-time ultrasound evaluation of body composition, and traits recorded were the 12th and 13th rib subcutaneous fat thickness (FT), longissimus muscle area (LMA), and percentage intramuscular fat (IMF). Performance data provided by the International Brangus Breeder’s Association (IBBA) included: birth weight (BRW), weaning weight (WWT), yearling weight (YWT), and scrotal circumference (SC). Data were analyzed to determine genetic relationships with the animal model using multiple trait restricted maximum likelihood (MTDFREML) procedures. Contemporary group was included in the model as a fixed effect, and age of days was included as a covariate. Analyses of covariant models were examined to determine the relative importance of sire and carcass traits to percentage IMF. Genetic correlations of IMF with LMA, FT, and YWT were –0.25, 0.36, and 0.31, respectively, indicating that as LMA increased IMF decreased. Sire, FT, and LMA were important (P < 0.05) sources of variation in percentage of IMF; BRW, WWT, YWT, SC, and age did not (P > 0.05) influence percentage IMF. These data suggest that percentage of IMF is under genetic control of a quantitative nature, and therefore should be considered when selecting for increased quality grade.
icle (U.S.D.A. beef carcass grade standards) using the cross sectional longissimus muscle image. A single longitudinal image of the longis-
simus muscle was taken (included the 11-12-13th ribs) for calculation of IMF.

In this study, data were edited to ensure uniformity of the equip-
ment, software, and guidelines of the IBBA. Only purebred Brangus
bulls and heifers intended to be used in the future as seedstock or
replacement animals were in the data set. According to IBBA guide-
lines, yearling animals are considered 365 ± 45 days of age. Therefore,
yealring weights were only considered from those animals
weighed within 45 days of a year of age. Animals must have also had
a measurement recorded for IMF to be included in the data set.
Animals remaining in the data set were divided into contemporary
groups based on sex, breeding season, and environment for restricted
maximum likelihood analysis. Contemporary groups containing only
one sire were eliminated from the data set. Represented in 21 con-
temporary groups were the progenies of 297 sires. Descriptive statistics
for the edited data set used for analysis are shown in Table 1.

Single-trait animal models were used to estimate starting vari-
ces for subsequent multiple-trait analysis. All possible combina-
tions of multiple-trait analysis were performed two traits at a time.
This procedure fits an additive genetic effect for animals with records
as well as all parents analyzed in the pedigree database. Genetic
parameters were estimated for LMA, FT, IMF, and YWT. There were
not enough data points for the traits of BRW, WWT, and SC for
MTDFREML to converge on permissible heritabilities and correla-
tions. Prior to variance component estimation, the MIXED procedure
of SAS (SAS Inst., Inc., Cary, NC) was used to determine the signif-
icance of fixed effects for contemporary group, days of age, and the
interaction of contemporary group x days of age for inclusion into the
final animal model. In addition, starting variance components for the
Multiple Trait Restricted Maximum Likelihood program of Boldman
et al. (1993) and Boldman and Van Vleck (1991) were also estimated
using MIXED procedures. Contemporary group was significant (P <
0.001), the linear effect of days of age was significant (P < 0.001), but
the interaction of contemporary group x days of age was not signifi-
cant (P > 0.05). Therefore, contemporary group was included in sin-
gle and multiple-trait animal models as a fixed effect, and days of age
was included in the models as a covariate. Analyses of covariance
models were examined using GLM procedures of SAS (SAS Inst.,
Inc., Cary, NC) to determine significant effects of LMA, FT, BRW,
WWT, SC, days of age, and sire on IMF. Sire was considered as a
random variable, and the test option was used to ensure that proper F-
tests were computed. Days of age was included in the model as a
covariate. Interactions and main effects were tested, however interac-
tions were not significant and therefore not included in the final
model.

Results and Discussion

Sire effects. Sire had a significant effect on the expression of IMF (P = 0.0004). Approximately 32% of the variation for IMF was
accounted for by the sire term of the model used in the analysis. The
Brangus sires represented in these data produced progeny that aver-
aged about 3.5% IMF. Mean and coefficients of variation for IMF of
10 bulls with 10 or more progeny are presented in Table 2. Some of
the sires represented produced progeny that averaged up to 6.9%
IMF. There is sufficient variation in IMF to support artificial selec-
tion for genetic change in the trait.

Carcass Traits. Longissimus muscle area had a significant effect
on the expression of IMF (P = 0.03). The genetic correlation between
these two traits was −0.25. This correlation is in agreement with the
−0.21 between LMA and marbling score reported by Koots et al.
(1994), in a review of published literature. However, Wilson et al.
(1993) found a much lower correlation of −0.04 between LMA and
marbling score. The moderately low, negative correlation found in
this study indicates that as LMA increases IMF will tend to decrease.
This relationship is not fully understood, but could be due in part to
the position on the growth curve of the animals involved. Breeding
cattle are usually managed for growth. At one year of age, Brangus
cattle in this study were likely still growing with little impetus for fat-
tening. Twelfth-rib fat thickness was also found to have a significant
effect on the expression of IMF (P < 0.0001), and a moderately pos-
tive genetic correlation of 0.36 (Table 3). The correlation found in
this study is in agreement with both Wilson et al. (1993) and Koots et
al. (1994) who found correlations of 0.38 and 0.35, respectively, for
FT and marbling score. This relationship is however antagonistic on
a value based pricing system. Brethour (2000) reported that when
feeding cattle to achieve a desired quality grade, yield grade would
most likely suffer. It was found that external fat increases at a much
quicker rate than IMF during the fattening period. Selection of the
proper sires, ones that have high breeding value for IMF and percent-
age retail product, could possibly allow the progeny to achieve a high
quality grade without having to sacrifice yield grade.

Growth Traits. Birth weight, WWT and YWT did not (P > 0.05)
have a significant effect on the variation found in IMF. As SC
increased, IMF slightly decreased, indicating that selection for
increased SC might have an antagonistic effect on IMF. This relation-
ship could be explained by the fact that bulls that are not castrated
will produce testosterone and have a longer growth curve, therefore
causing them to deposit muscle longer, and deposit fat at a later stage
in the life. Days of age also approached significance on the expres-
sion of IMF (P = 0.11). Brethour (2000) demonstrated that as days on
feed increased so did the amount of IMF that was deposited. This is
likely a response to the fact that as an animal matures, muscle accre-
tion decreased and fat deposition increases.

Implications

Percent intramuscular fat is under quantitative influence, and
there are many traits that may affect it. In this study approximately
one-third of the variation of IMF was accounted for by variation due
to sire. Therefore, selection for sires could be the best way to cause
an increase in the amount of IMF. However, in the real world of ani-
mal breeding, selection for a single trait is rare, because breeders typ-
ically are interested in improving a number of traits.

Literature Cited

of programs to obtain estimates of variances and covariances.
ARS, USDA, Washington DC.
Falconer, D. S., and T.F.C. MacKay. 1996. Introduction to quantita-
tive genetics. 4th Ed. Addison Wesley Longman Limited, Essex,
England.
Table 1. Descriptive statistics for edited data

<table>
<thead>
<tr>
<th>Trait</th>
<th>Number of Records</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFAT(^a), %EE</td>
<td>1,215</td>
<td>3.27</td>
<td>0.92</td>
</tr>
<tr>
<td>LMA(^a), in(^2)</td>
<td>1,214</td>
<td>11.10</td>
<td>2.28</td>
</tr>
<tr>
<td>FT(^a), in</td>
<td>1,214</td>
<td>0.22</td>
<td>0.11</td>
</tr>
<tr>
<td>BW(^b), lb</td>
<td>323</td>
<td>84.04</td>
<td>10.23</td>
</tr>
<tr>
<td>WW(^b), lb</td>
<td>328</td>
<td>641.32</td>
<td>59.27</td>
</tr>
<tr>
<td>YW(^a), lb</td>
<td>1,087</td>
<td>1,028.52</td>
<td>191.27</td>
</tr>
<tr>
<td>SC(^b), in</td>
<td>329</td>
<td>15.01</td>
<td>1.04</td>
</tr>
</tbody>
</table>

\(^a\) LMA = 12th-rib longissimus muscle area, ultrasonically measured on live yearling bulls and heifers; FT = 12th to 13th-rib fat thickness, ultrasonically measured on live yearling bulls and heifers; PFAT = percent intramuscular fat from 12th-rib longissimus muscle area, ultrasonically measured on live yearling bulls and heifers; YW = live weight of yearling bulls and heifers taken at time of ultrasound.

\(^b\) Measurement was recorded by producer and obtained from sale catalogs for: BW = birth weight; WW = weaning weight; SC = scrotal circumference.

Table 2. Variation in intramuscular fat by sire progeny group

<table>
<thead>
<tr>
<th>Sire No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>21</td>
<td>38</td>
<td>11</td>
<td>26</td>
<td>13</td>
<td>10</td>
<td>15</td>
<td>25</td>
<td>12</td>
<td>29</td>
</tr>
<tr>
<td>Mean, %</td>
<td>3.72</td>
<td>3.00</td>
<td>2.80</td>
<td>3.42</td>
<td>3.36</td>
<td>3.35</td>
<td>2.58</td>
<td>3.21</td>
<td>2.90</td>
<td>3.58</td>
</tr>
<tr>
<td>CV</td>
<td>15.1</td>
<td>34.0</td>
<td>26.7</td>
<td>16.3</td>
<td>18.7</td>
<td>13.7</td>
<td>62.0</td>
<td>17.9</td>
<td>39.6</td>
<td>19.3</td>
</tr>
</tbody>
</table>

Table 3. Heritabilities estimated from two-trait models and correlations for estimates of ultrasonic carcass characteristics

<table>
<thead>
<tr>
<th>Trait(^b)</th>
<th>LMA</th>
<th>FT</th>
<th>IMF</th>
<th>YW</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMA</td>
<td>0.31</td>
<td>-0.09</td>
<td>-0.25</td>
<td>0.44</td>
</tr>
<tr>
<td>FT</td>
<td>0.16</td>
<td>0.27</td>
<td>0.36</td>
<td>0.42</td>
</tr>
<tr>
<td>IMF</td>
<td>-0.08</td>
<td>0.17</td>
<td>0.15</td>
<td>0.31</td>
</tr>
<tr>
<td>YW</td>
<td>0.44</td>
<td>0.33</td>
<td>0.03</td>
<td>0.53</td>
</tr>
</tbody>
</table>

\(^a\) Heritability estimates on diagonal, genetic correlations above diagonal, phenotypic correlations below diagonal.

\(^b\) LMA = 12th-rib longissimus muscle area, ultrasonically measured on live yearling bulls and heifers, in cm\(^2\); FT = 12th to 13th-rib back fat thickness, ultrasonically measured on live yearling bulls and heifers, in cm; IMF = Percent intramuscular fat from 12th-rib longissimus muscle area, ultrasonically measured on live yearling bulls and heifers; YW = Live weight of yearling bulls and heifers taken at time of ultrasound, in kg.